U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

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High-Density Polyethylene (HDPE) Buried Piping for Class 3 Safety-Related Applications

Motivation for Using HDPE Piping

Service Water Piping Corrosion

Nuclear power plant service water piping may experience leaks and flow restriction because of various corrosion and fouling mechanisms such as general corrosion, galvanic corrosion, and microbiologically induced corrosion. These degradation mechanisms affect both nonsafety and safety-related piping systems.

Example of corroded steel service water piping. (courtesy of Duke Energy)

For Nonsafety Service Water Piping

Plants have replaced steel piping with HDPE piping because it is immune to service water corrosion and is highly resistant to fouling. For example, Duke Energy has been using HDPE piping in nonsafety-related applications for over 12 years with no corrosion or fouling problems.

Benefits of Using HDPE Piping

HDPE piping is immune to corrosion and is highly resistant to fouling. Fabrication is performed by thermal fusion and can be performed more rapidly than steel welding. HDPE piping is very flexible and able to withstand significant displacements in response to soil movement. HDPE piping can be produced in a wide variety of diameters and thicknesses (for example, pipes with a diameter of 36 inches and a wall thickness of about 4 inches have been produced).

Examples showing the degradation resistance of HDPE piping. (courtesy of Duke Energy)

Example of HDPE piping in nonsafety service water piping. *(courtesy of Duke Energy)*

HDPE Piping for Class 3 Safety-Related Piping

Some licensees have requested U.S. Nuclear Regulatory Commission (NRC) approval to replace steel piping with HDPE piping in American Society of Mechanical Engineers (ASME) Class 3 (Class 3) safety-related applications. However, Class 3 safety-related piping is governed by ASME Code Section III & XI requirements. The NRC has not endorsed the ASME code requirements for HDPE piping. Therefore, HDPE can only be used on a case-by-case basis with NRC approval.

The NRC has approved the use of HDPE piping for specific safety-related applications at the Catawba Nuclear Station and Callaway Plant via relief requests. The approvals are for a limited time, but they may be extended if adequate performance is demonstrated. The HDPE piping system requirements were based on ASME Code Case N-755.

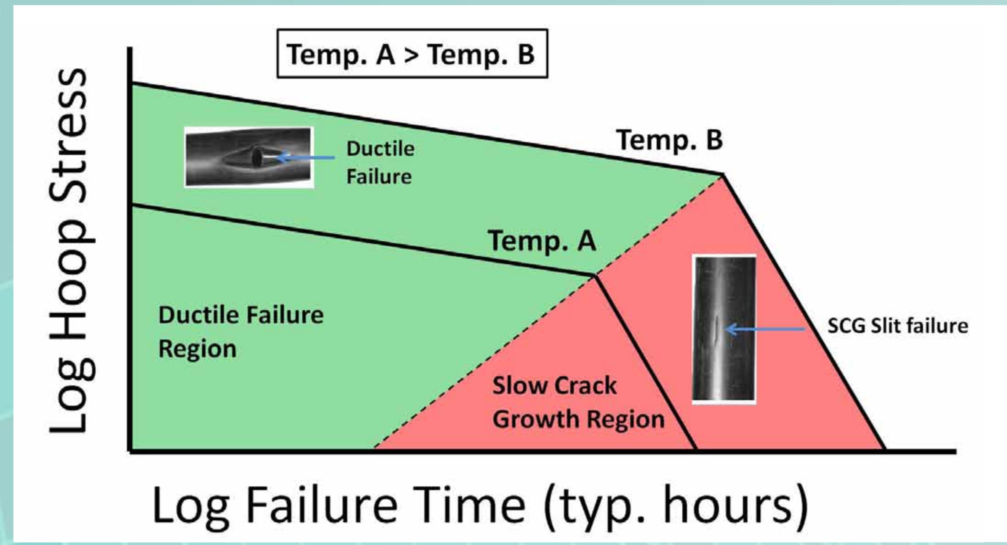
ASME Code Case N-755

ASME Code Case N-755 was developed to set forth the requirements for using HDPE piping in Class 3 safety-related applications. ASME has approved Code Case N-755, but the NRC has not endorsed N-755 for concerns related to (1) the technical basis for demonstrating piping integrity of a flawed pipe under the proposed service conditions, (2) the fusion procedures and qualification, and (3) the non-destructive examination procedures and qualifications.

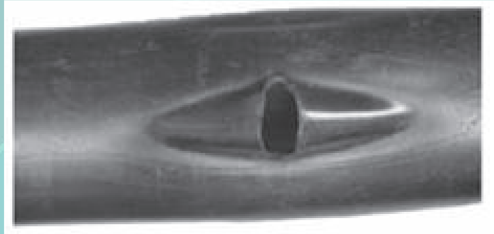
Issues and Research Related to the Use of HDPE Piping in Safety-Related Applications

Slow Crack Growth

Slow crack growth (SCG) is the primary mode of failure in service for HDPE piping. It is characterized by a low-ductility slit-like failure with little gross deformation of the area surrounding the failure. Regardless of the failure mode, failure times decrease exponentially with increasing sustained temperatures. The relationship between ductile and SCG slit-like failure modes as functions of hoop stress and temperature is shown in the figure on the right. The transition from ductile failure to SCG failure is indicated by the knee in the curve.

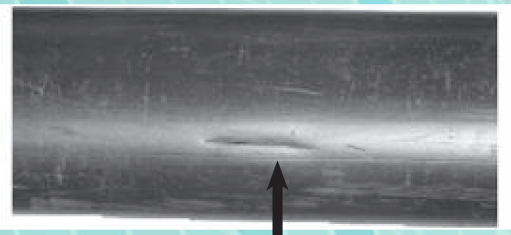


Schematic of hydrostatic testing results for HDPE piping showing ductile and SCG failure regions. The knee in the curve indicates the transition from a ductile failure mode to an SCG failure mode.



Ductile Failure Appearance

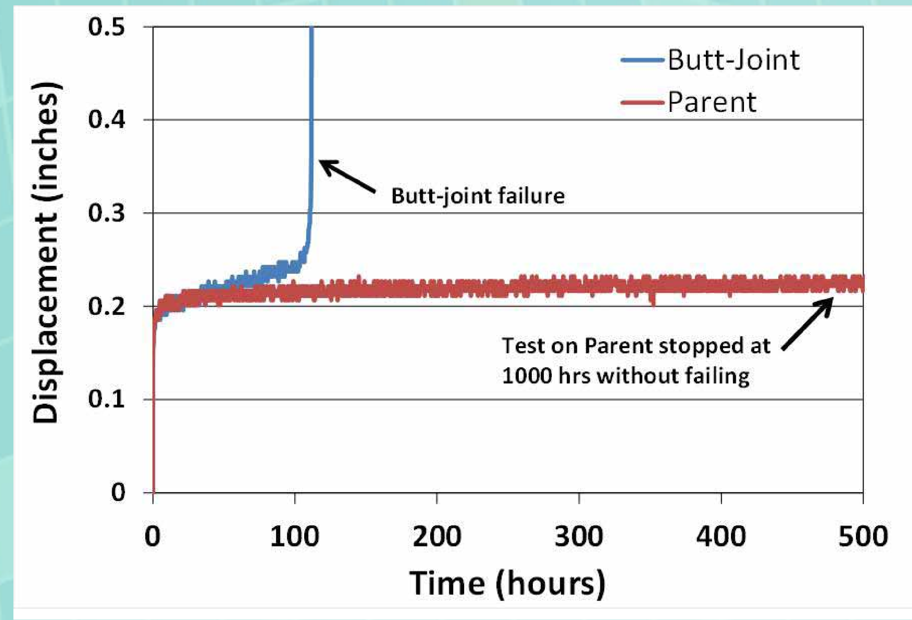
HDPE Piping Hydrostatic Test Specimens
(ref. BASF)



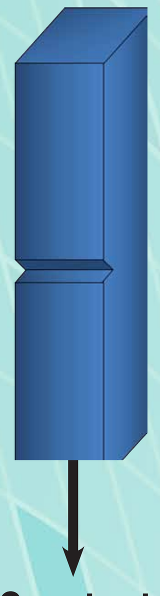
SCG Slit-Like Failure Appearance

NRC Research Activities.

The Office of Nuclear Regulatory Research is conducting confirmatory research on the proposed requirements in ASME Code Case N-755. Research is focused on (1) the technical basis for demonstrating piping integrity of a flawed pipe under the proposed service conditions, (2) verifying nondestructive examination procedures and qualification requirements. (4) verifying fusion procedures and qualifications requirements.



NRC Research: SCG testing of a HDPE piping fusion joint and parent pipe materials containing a flaw tested at 176 °F and an initial stress of 400 psi. The flaw depth was 25% of the specimen thickness. The HDPE parent material exhibited failure times greater than 1000 hrs.



Constant Load